CAN ORGANIC LIFE EXIST IN THE PLANETARY SYSTEM OUTSIDE OF THE EARTH?

By C. A. Stetefeldt.

In the following discussion I hold to the principle, expressed in Newton's *Regulæ Philosophandi*, that in explaining any phenomena taking place outside of our Earth, we must not assume the existence of new and unknown forces and properties of matter. On the contrary, the more our knowledge of the universe progresses, the more we become convinced that the phenomena observed on the Earth only repeat themselves on a smaller or grander scale in every nook of infinite space.

Philosophers have told us that the universe has no reality, but exists only in our imagination. Gravity would still exist if there were no arms to lift; sound-waves would exist if there were no ears to hear; light and heat-waves would exist if there were no eyes to see and no nerves to feel. These philosophers should have said: The imperfections of our sensory organs fail to bring to our consciousness thousands of modes of energy that have a real existence. On the whole, speculative philosophy, not based on the real, has done almost nothing to widen the horizon of our knowledge of the universe.

Scientists, however, should not throw stones at these philosophers when many of the former have themselves lived in glass houses. I refer here to certain strange speculations advanced, in violation of all known laws of physics and biology, by some astronomers in regard to the existence of organic life and rational beings on the stars, the Sun, and the planets and their satellites.

So far as the habitability of the Sun and the fixed stars is concerned, we might dismiss this at once. I quote, however, the strange hypothesis of the Sun's photosphere, brought forward by Sir William Herschel,* which assumed that the nucleus of the Sun was actually cold,—cold enough to sustain organic life—and that the heat and light we receive was generated in a mysterious way in the Sun's atmosphere, high above its solid body. How the Sun's inhabitants escaped destruction, the hypothesis did not sufficiently explain. It is also stated that the Sun-spots are

* With the theory of heat current in Herschel's time, his conclusions were not by any means so absurd as they would be to-day.

holes or windows in the upper photosphere, made by the Creator for the purpose of enabling the solar astronomers to get a glimpse of the universe of which they would remain in entire ignorance otherwise.

We must, however, acknowledge that if other Suns in the universe have planets—and there is no reason why they should not—many of them may present physical conditions identical with or similar to those existing on Earth, and that therefore their organic life may be similar to our own. Further, I am far from denying that under favorable circumstances creatures may be evolved upon planets which revolve around other suns, whose mental capacity is as much superior to man's as that of the latter is to the lowest forms of our vertebrates.

I remark here that our imagination is strictly confined to reproducing the images of terrestrial forms and phenomena, the impressions of which our senses have left upon the brain. The human form has always been, and is now, the artist's ideal of beauty, and beyond he cannot go. Wherever an attempt is made to represent anything super-human, attributes are derived from animals lower than man. Thus, we see horns on the head of MICHAEL ANGELO'S Moses; angels appear with the conventional wings of birds; the devil has a tail and a cloven foot. MICHAEL ANGELO represents in his fresco "The Creation of Eve" the god of Christianity as an old man with a long, white beard; the holy ghost always appears as a dove; heaven and hell, as depicted by DANTE and MILTON, could be easily set in scene on the stage of a theatre. The gods described by the poets of the ancients were only men and women in disguise; and even God, as described by some Christian theologians, is a being with purely human attributes, sitting on a throne in heaven, surrounded by an army of winged angels.

If we acknowledge the uniformity of matter in the universe, and spectrum analysis leaves us no other alternative; if we acknowledge that chemism is everywhere the same, at least at that stage in the development of a planetary system when the celestial nebulæ have commenced to condense,—and we have no reason to assume otherwise:—then the physical conditions for the existence of organic life are exceedingly limited, *i. e.*, they depend on certain temperatures and atmospheric densities and constitution. Organisms, while they can live through spells of temperature much below the freezing-point of water, do not thrive at such

temperatures; they are killed at the boiling-point of water at normal atmospheric pressure, and all so-called organic compounds decompose completely at higher temperatures.

Paleontology teaches us that a continuous progress took place in the evolution of organic life caused by comparatively slight changes in temperature and atmospheric conditions.

At the time when the first protoplasm was formed we may assume that the Earth was not as cold as it is now, that its crust had not yet attained sufficient thickness to prevent the conduction of internal heat to the surface; and judging from the enormous deposits of coal and mineral oil in its strata, the atmosphere may have contained originally a much larger percentage of carbonic acid than at present, thus favoring a more luxurious growth of plants. The latter facts, the higher temperature, and in consequence, the greater quantity of water in the atmosphere, by which more intense atmospheric disturbances were produced, prevented at that time the evolution of organisms of the highest type. In examining the distribution of organic life on the Earth, it is easily seen how narrow are the limits for the existence of the highest types. Compare the flora and fauna of the equatorial and polar zones, and note that man, the noblest of beasts, finds his highest mental development only in the temperate zone.

But there are other points to consider: I contend that in order to sustain high types of life on a planet or satellite a certain density of its atmosphere is necessary; that its period of rotation round its axis should not be too long; that the planet should not be too far distant from the Sun.

Concerning the first proposition, it is evident that if the atmospheric density is almost imperceptible, life cannot be sustained at all, and that an enormous density would prevent at least the existence of higher organisms, even if they easily accommodated themselves to great pressure, on account of the destructive influence of atmospheric phenomena. Consider the effect of a Kansas cyclone, and imagine the result if our atmosphere had a density a thousand times greater.

Concerning the second proposition, it is clear that if the time of rotation of a planet round its axis is unreasonably long, as, for instance, with the Moon, the difference in temperature between day and night, other conditions being equal, would be so great that high types of life could not be evolved. Paleontology and the distribution of living organisms on our globe point to the fact

that evolution was most intense, and reached its highest types, where favorable atmospheric conditions were most uniform. Our ancestors, the apes, were not born on the north pole.

Finally, if planets are so far removed from the Sun that the light and the heat they receive is only a small fraction of that supplied to our Earth, the conditions for sustaining high types of organic life cannot be favorable either. The annexed table, with figures referring to the most important planets, explains itself. It is not necessary to consider satellites outside of the Moon, or the army of minor planets with diameters of not much above 200 miles down to a few miles. The figures quoted are taken from *Young's Astronomy*, edition 1888, with exception of the atmospheric densities.

Regarding the atmospheres of planets, astronomers have made some strange statements. The only rational treatment of this subject I found in ZOELLNER'S *Die Natur der Cometen*, and the atmospheric densities given in the table are calculated from ZOELLNER'S equation. According to well-known physical laws, the density of so-called permanent gases on the surface of a planet, or any celestial body, must be a function of gravitation on its surface, and of its radius. But I go further and contend: (1) That all planets of the solar system must have atmospheres of permanent gases similar in composition to our own atmosphere. (2) That it is untenable to speak of the limitation of an atmosphere; that, on the contrary, the whole interplanetary and interstellar space must be filled with these exceedingly attenuated gases. (3) That if a new planet were put in this space, it must collect and abstract from the atmospheres of other bodies an atmosphere corresponding to its own mass and radius.

Besides, there are gases and vapors in planetary atmospheres which distribute themselves according to DALTON'S law, and which follow the laws of MARIOTTE and GAY LUSSAC only within certain limits. I refer here, principally, to the existence of water in planetary atmospheres. Various observations leave no doubt that water, in one or more of its states of aggregation, is present on all the planets, and especially on the smaller ones.

I call attention to the low specific gravities of the Sun and the four large planets. Let us first consider the Sun. The disk of the Sun, as it appears to the naked eye and through the telescope, does not represent the actual surface of the Sun's liquid or partly solid nucleus, but the latter plus the photosphere, *i. e.*, the

envelope of highly incandescent gases, vapors, and floating, condensed particles. Beyond the photosphere is an extensive atmosphere of permanent gases, principally hydrogen, called the chromosphere. We cannot ascertain the height of the photosphere, and consequently can have no knowledge of the actual diameter and specific gravity of the Sun's nucleus.

A similar argument holds good for the large planets *Jupiter*, *Saturn*, *Uranus*, and *Neptune*. There seems to be no doubt that these planets have not yet cooled down as much as the Earth and the other smaller planets; that, on the contrary, they still radiate a considerable amount of their own heat. This would necessarily lead to the formation of very dense, cloudy envelopes, and to the enlargement of their visible disks far beyond the diameters of their solid bodies.

ZOELLNER'S equation, from which the atmospheric densities have been calculated, is as follows:

$$Log.\ nat.\ \frac{d}{d_1} = \frac{1}{a.\ a.}\left(\frac{g.\ r.}{t} - \frac{g_1\ r_1}{t_1}\right)$$

d Density of air on surface of planet.

g Gravitation " " "

r Radius of planet.

t Absolute temperature of the space in which the planet exists.

d_1, g_1, r_1, t_1 The same values for the Earth.

$\frac{1}{a}$ Absolute temperature of melting ice.

a Constant for air.

The following values are assumed:

$$d_1 = 1;$$
$$g_1 = 0.00981 \text{ kilometres};$$
$$r_1 = 6367.4 \text{ kilometres};$$
$$\frac{1}{a} = 273;$$
$$a = 0.07838.$$

For the sake of simplicity we put

$$t = t_1 = 273^\circ\ C.$$

This gives the equation:

$$Log.\ nat.\ d = 12.76\ (g\,r - 62.46).$$

The atmospheric densities thus obtained are not entirely correct, but close enough to the truth for our purposes. It is evident that in putting $t > t_1$, for *Venus* and *Mercury*, the equation would give still higher negative values, *i. e.*, still lower densities; and putting $t < t_1$, for the four large planets, their atmospheric densities would be still greater. The same notation holds good if we assume a lower absolute temperature for interplanetary space. In all cases we obtain almost imperceptible densities for the Moon and the small planets, and enormous figures for the large planets. Outside of this, a correction would have to be made dependent on the temperature of the planet's surface which, however, would not change results materially either, *i. e.*, so far as the question at issue is concerned.

The enormous atmospheric densities of the large planets, as deduced from ZOELLNER'S equation, lead us to another interesting consideration. It is hardly necessary to state that these figures can have no real existence, or the apparent specific gravities of the Sun and the large planets would be much greater. They result in consequence of a deficiency in ZOELLNER'S equation which assumes that MARIOTTE'S law has no limitation. Although there exists, according to ANDREWS, for each gas a critical temperature above which no amount of pressure can convert it into a liquid, the law of MARIOTTE, or a similar law, cannot even then hold good for unlimited pressure. Whenever a certain limit has been reached, the gas acts like a liquid, *i. e.*, increased pressure fails to reduce its volume. According to the atomic theory of matter and ether, the atoms are rigid and of distinct shape. When the ether-spheres have been compressed to the last limit, and the molecules of matter have been brought to the least possible distance, no amount of pressure can produce a further reduction of volume. I am not aware that experiments have been made to settle this question for any gas at a temperature above the critical point. These defects in ZOELLNER'S equation, however, do not influence results as a whole, *i. e.*, the fact remains that the smaller planets must have almost imperceptible atmospheres, and the large planets enormously dense ones.

Finally, we have to take into consideration that the temperature on the surface of a planet depends not only on its distance from the Sun, *i. e.*, on the quantity of heat received, but also on the density of its atmosphere. If the latter is exceedingly slight, the heat cannot be retained but is radiated back into space as fast

as received. In proof of this, I only need to remind the reader that even in the equatorial zone high mountains are covered with eternal snow.

On planets with slight atmospheres of permanent gases a lively evaporation of water, if such be present, must take place, and these atmospheres must contain more water-vapor than air. This, as will be seen later on, is actually the case.

The Moon.

A glance at the figures in the following table is sufficient to show that the lunar citizen and his flower garden are a chimera. Hence, we might dismiss this matter without further argument; but it is of interest to obtain more proof by actual observation. The telescopic appearance of the Moon gives no evidence of atmospheric phenomena. There is absolutely no refraction when the Moon passes between us and a star. The lunar spectrum is exactly like the Sun's, being only reflected sunlight. The heat we receive from the Moon is so slight that exact measurements do not exist. A large portion of it is reflected sun-heat; the rest is obscure heat, *i. e.*, heat which has been first absorbed by the Moon's surface and then radiated. Again, a portion of the latter in the lunar heat-spectrum consists, according to Langley's measurements with the bolometer, of heat-waves having a greater length than waves radiated from a block of ice. Hence, the temperature on the Moon's surface must be very low. But why is the temperature on the Moon so low when a lunar day is so long, the Sun shining uninterruptedly for fourteen days on the same spot? The explanation is exceedingly simple. In the first place, the lunar atmosphere being practically non-existent as compared with our own, heat cannot be retained on the Moon's surface. Then it is held by some astronomers that a considerable portion of the Moon's surface is covered by ice and snow. By evaporation of the ice the Sun's heat is absorbed, and the water-vapor travels to the Moon's side averted from the Sun, where it again condenses. But if so, would not this vapor show atmospheric phenomena, *e. g.*, refraction of light? This does not follow; according to Zoellner's calculations even this atmosphere of water-vapor is so attenuated that it would escape observation.

Astronomers, however, were grieved to rob Luna of her man, and Hansen gallantly embraced her cause. He calculated that the center of the Moon's gravity is some thirty miles farther from us

than the center of its figure, *i. e.*, the side of the Moon we see is bulged out. Thus, a table-land of enormous height exists on this side of the Moon, with an imperceptible atmosphere, while the other side, averted from us, is provided with an ample atmosphere, breathed by happy lunar citizens. They have, however, one great sorrow: They can never get a glimpse of the Earth, because it means death to them to take a trip to the highlands. HANSEN'S conclusions have been shown to be unwarranted by facts; but assuming that they were correct, the Moon's atmosphere would not be perceptible even on the depressed side.

MERCURY.

Outside of an almost imperceptible atmosphere of permanent gases, which would exclude organic life, *Mercury* presents another ugly feature. The eccentricity of his orbit is so large that he receives $2\frac{1}{4}$ times more heat near perihelion than near aphelion. Being so near the Sun, he receives, in the mean, $7\frac{6}{10}$ times as much light and heat as the Earth. All this must cause the most violent climatic changes under which no highly organized forms of life could very well exist. That *Mercury* has, however, a perceptible atmosphere of water-vapor is proved by lines in his spectrum and by phenomena observed at transits, and this is not surprising in consideration of the large amount of heat received from the Sun, by which a lively evaporation of water must be effected.

VENUS.

Venus shows neither very conspicuous surface-markings nor atmospheric phenomena. The spectroscope proves the presence of water in her atmosphere, and the latter becomes especially perceptible in transits, *i. e.*, when *Venus* passes between the Earth and the Sun. Unfortunately, these transits are rare. The last one took place in 1882, and the next one will occur in 2004. I quote from *Young's Astronomy:* "When the planet is near the Sun, the horns of the crescent extend notably beyond the diameter, and when very near the Sun, a thin line of light has been seen by several observers to complete the whole circumference. This is due to refraction of sunlight by the planet's atmosphere, a phenomenon still better seen as the planet is entering upon the Sun's disk at a transit, when the black disk is surrounded by a beautiful ring of light."

I beg to disagree, however, with the following conclusion,

based on the above observations: "Its atmosphere is probably from one and a half to two times as extensive and dense as our own."

Photometric researches, namely, the high albedo and the peculiar distribution of light in the phases of *Venus*, especially the great light-intensity of small phases, make it highly probable that this planet is largely covered by water. And considering that *Venus* receives nearly twice as much sunlight and heat as the Earth, evaporation of water must be very intense in its rarified atmosphere of permanent gases. This atmosphere of water-vapor would fully account for the phenomena observed without assuming the correctness of the statement regarding atmospheric density and extent.

In fact, observations made by different persons, at the same time, and at different transits, do not agree at all, and leave it doubtful how much of the phenomenon is reality and how much optical illusion.

In Mercurial transits similar phenomena, but of less intensity, are observed.

Mars.

Mars shows evidence of polar ice-caps changeable with the seasons. The latter must be more pronounced than with us, the inclination of equator to orbit being slightly, and the eccentricity of orbit very much, greater. There are other distinct markings on this planet which have the appearance of land and sea. The spectroscope proves the presence of water in its atmosphere. Its attenuated atmosphere of permanent gases, which it shares with the Moon, *Mercury* and *Venus*, would positively exclude life in this as well as in all other cases.

Jupiter, Saturn, Uranus and *Neptune.*

All observations, into which I need not enter here in detail, prove that *Jupiter* and *Saturn* have not yet cooled down like the smaller planets; but still retain considerable heat and are slightly self-luminous. This is not surprising if we consider their enormous masses, and that according to investigations of Buffon, Bishop and others, the time required for cooling a hot body increases very rapidly with an increase of its mass. The atmospheric disturbances of these planets are so violent that they could not be produced by the Sun's heat alone which, as we find in the table, is only about $\frac{4}{100}$ and $\frac{1}{100}$ respectively of that received by

the Earth. This would at once negative the existence of organic life. The same argument holds good for *Uranus* and *Neptune*, but in a less degree. They are so far removed from us that observation of their atmospheric phenomena becomes very difficult. While they must be much cooler than *Jupiter* and *Saturn*, and may not be self-luminous, they evidently still retain a high temperature as indicated by their spectra. Assuming, however, that *Neptune*, for instance, had cooled down completely, he would receive only about $\frac{1}{1000}$ of the Sun's light and heat we get. So far as light is concerned, this would not be so bad ; it would still be equal to a one thousand candle-power electric lamp at a distance of 10½ feet. By far the larger portion of the light, however, would be absorbed by the dense, enormous atmosphere of the planet, and it is questionable whether the disk of the Sun would ever be visible on its surface, and a direct ray of sunlight be able to penetrate the gloom. On account of the great atmospheric density, sufficient heat from the Sun may be retained on the surface of the planet to support organic life. But even then, *i. e.*, after cooling down sufficiently, this planet and the other large ones could only evolve certain low forms of living creatures on account of the enormous atmospheric densities and corresponding atmospheric disturbances.

In concluding this investigation we cannot help admiring the inductive acumen of the theologians who considered the Earth the most important of the planets, and the center of creation. Although their opinions were not based upon scientific facts, they arrived at the truth, nevertheless.

	Mass. Earth = 1.	Mean Diameter. Earth = 1.	Specific Gravity. Earth. = 1.	Specific Gravity. Water. = 1.	Mean Gravity at Surface. Earth = 1.	Product of Gravity and Radius in Kilom.	Atmospheric Density at Surface. Earth = 1.	Light and Heat Received. Earth = 1.	Time of Axial Rotation.	Eccentricity of Orbit.	Inclination of Equator to Orbit.
SUN	331100	109.4	0.25	1.39	27.65	. . .	. . .	. . .	. . .	. . .	. . .
MERCURY.	0.066	0.380	1.26	7.14	0.47	11.15	$\frac{1}{10^{284}}$	6.7	Practically the same	0.2056	?
VENUS	0.78	0.972	0.86	4.85	0.83	50.38	$\frac{1}{10^{67}}$	1.93	for the four small	0.0068	?
EARTH	1.00	1.00	1.00	5.58	1.00	62.46	1	1.00	planets.	0.0167	23° 27′
MOON	0.0123	0.273	0.61	3.40	0.166	2.83	$\frac{1}{10^{328}}$	1.00	27^d 7^h	. . .	. . .
MARS	0.107	0.534	0.72	4.01	0.38	12.67	$\frac{1}{10^{275}}$	0.44	. . .	0.0932	24° 50′
JUPITER	316	10.92	0.24	1.33	2.65	1807.47	10^{9670}	0.0372	About 10^h for	0.0485	3° 05′
SATURN	94	8.87	0.13	0.72	1.18	661.07	10^{3323}	0.0111	these two.	0.0560	26° 49′
URANUS	14.7	4.03	0.22	1.22	0.91	229.04	10^{923}	0.0026	?	0.0463	?
NEPTUNE.	17.1	4.39	0.20	1.11	0.88	241.28	10^{990}	0.0011	?	0.0089	?